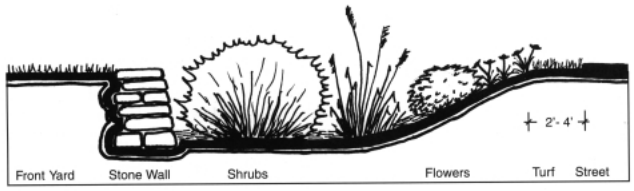
On-Lot Infiltration



General Description

On-lot infiltration systems promote infiltration at the individual lot level, controlling runoff at its source. These systems are off-line and generally receive sheet flow runoff. The main feature that distinguishes these systems from other infiltration systems (such as infiltration basins and trenches) is scale. These small systems accept runoff from a single residential lot. Although infiltration basins and trenches have many design features in common with on-lot infiltration systems, the Infiltration Basins and Infiltration Trenches BMP Sections refer to larger lot, end-of-pipe facilities.

On-lot infiltration systems' primary function is to mitigate the normal impacts of urbanization on the natural water balance. This is done by turning water that would normally become surface runoff (a waste product) into a resource that waters trees, recharges groundwater and provides stream baseflows. On-lot infiltration systems also function to improve water quality by removing some pollutants from the runoff as it infiltrates. Also, because these systems serve to reduce the volume of runoff, they contribute to both erosion protection and flood control. Lastly, the use of these systems reduces the size and cost of downstream water control facilities.

On-lot infiltration systems include:

- Reduced lot grading (Figure 1)
- Directing roof leaders to soakaway pits (Figures 2 through 4)
- Directing roof leaders to rain barrels (Figure 6)
- Directing roof leaders or other surface runoff to other vegetated areas, such as rainwater gardens (Figures 7 through 10)

These source controls address measures that can be applied by the developer or the homeowner. Public education programs within municipalities can help to educate citizens on the role they can play in the application of these systems.

On-lot infiltration systems are not to be used for infiltrating any

Purpose

Water Quantity	
Flow attenuation	◧
Runoff volume reduction	■
Water Quality	
Pollution Prevention	
Soil erosion	**N/A**
Sediment control	**N/A**
Nutrient loading	**N/A**
Pollutant Removal (Soakaway Pits and Rainwater Gardens)	
Total suspended sediment (TSS)	■
Total phosphorus (P)	■
Nitrogen (N)	■
Heavy metals	■
Floatables	◧
Oil and grease	■
Other	
Fecal coliform	◧
Biochemical oxygen demand (BOD)	◧

■	Primary design benefit
◧	Secondary design benefit
□	Little or no design benefit

On-Lot Infiltration

runoff that could be significantly contaminated with sediment and other pollutants, such as runoff from high-potential pollutant loading areas like garages and gas stations.

In general, on-lot infiltration systems can be implemented for soil types of loam and coarser. Some authorities discourage infiltration systems at sites where soils have 30 percent or greater clay content, or 40 percent or greater silt content. A soils analysis is helpful in assessing the viability of infiltration systems. More detailed information on procedures for testing infiltration rates can be found in the Infiltration Basins and Infiltration Trenches BMP Sections. If native soils are considered to have a low infiltration capacity, filtration systems should be considered as an alternative to infiltration (see the Filtration Systems BMP Sections).

Advantages

- Can reduce the volume of runoff from a site, thereby reducing the size and cost of downstream stormwater control facilities.
- Can be utilized in retrofit areas where space is limited and where additional runoff control is necessary.
- Rainwater gardens can provide an aesthetically pleasing amenity when designed to support perennial flowers in the summer and display vividly colored or patterned shrubs in the winter.
- The potential for clogging of rainwater gardens is reduced compared to end-of-pipe infiltration techniques (infiltration basins and trenches) because these systems generally accept runoff only from roofs (roof drainage contains fewer suspended solids than road runoff) or driveways, lawns and sidewalks.
- Can be used at sites where storm sewers are not available.
- Can provide groundwater recharge.
- Flowering plants and ornamental grasses incorporated into the design of rainwater gardens are attractive to birds and butterflies.

Limitations

- Only applicable in small drainage areas of a half-acre or less.
- Water ponded on lots may take 24 to 48 hours to drain, which may restrict some of the use of the land.
- Some maintenance (unclogging soakaway pits, periodically removing sediment from rain barrels and rainwater gardens) is required to ensure the proper functioning of these systems. However, sediment accumulation is an indication that the infiltration techniques are working. This sediment would otherwise have washed downstream to a larger water body.
- Not recommended for lots with high sediment loadings or contaminated runoff.
- If the infiltration rate of the native soils is low, these systems may not function as desired.
- The bottom of these structures (with the exception of rain barrels) should be a minimum of 3 feet above the seasonally high groundwater table to prevent the possibility of groundwater contamination.

On-Lot Infiltration

Reduced Lot Grading

Description

Development standards often require minimum lot grades of 2 percent for adequate drainage of stormwater away from a building. Some authorities, however, have proposed reducing minimum lot grades from 2 to 0.5 percent to promote infiltration. This option is mainly intended to promote infiltration by slowing stormwater runoff from the roofs and yards and allowing it to soak into the lawn.

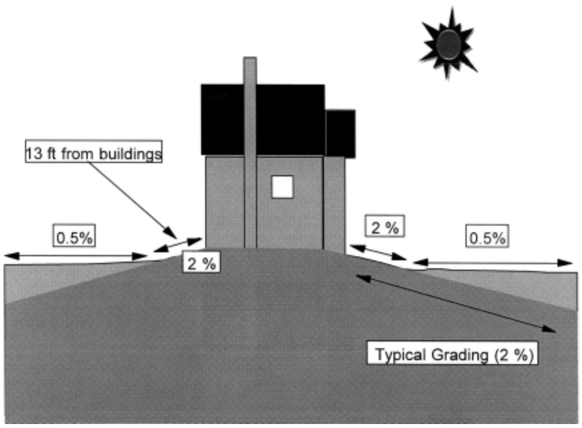
A reduction in the lot grading is generally a viable option if the land is naturally flat. In hilly areas, alterations to the natural topography should be minimized. Developers and homeowners should check the acceptability of this practice with the local municipality, because some municipalities may not permit its use.

Similarly, shallow depressions can be graded into lawns. Depressions need not be very deep to make a significant contribution to overall surface storage capacity and stormwater quality. For example, a square lawn area 50 feet on a side, sloping 2 percent toward the center, will create a low point 6 inches below the outside rim. This 6-inch slope over 25 feet of distance is barely noticeable, and is similar to standard grading practice for lawn areas. This 50-foot by 50-foot by 6-inch-deep lawn area creates a storage capacity of 413 cubic feet. If adjacent impervious surfaces, such as sidewalks, rooftops, and roads are designed to sheet flow into this concave lawn, their runoff can gradually infiltrate into the soil as well. Catch basins located at the upper edge of the concave vegetated surfaces can collect runoff from larger storms.

Figure 1 illustrates these lot grading changes on a residential lot.

Design Guidelines

- In order to ensure that foundation drainage problems do not occur, the grading within 6 to 12 feet of a building should be maintained at 2 percent or higher (local municipal standards should be reviewed to ensure that the grading around a building is in compliance). Areas outside of this boundary may be graded at less than 2 percent to create greater depression storage and promote natural infiltration.



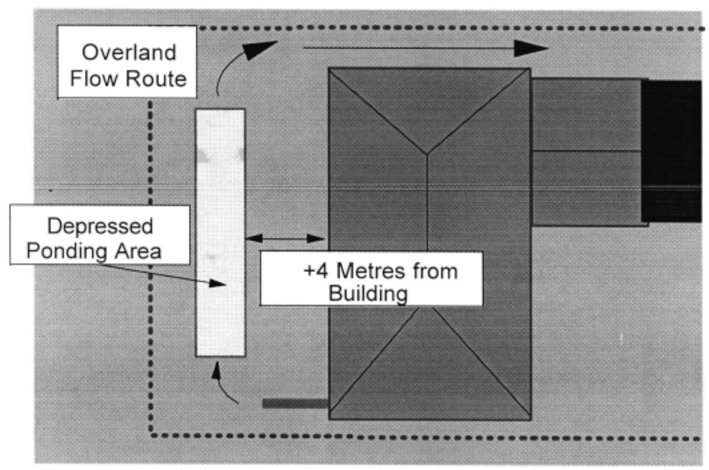


Figure 1: Examples of Lot Grading Changes
Source: Ontario Ministry of the Environment, 1999

On-Lot Infiltration

Reduced Lot Grading (continued)

- Infiltration can be improved by tilling (scarification) of the lots with flatter grading to a depth of approximately 12 to 24 inches before sod is laid. This would also be of general benefit in all residential areas to address the problems associated with soil compaction (loss of recharge potential) which occurs during construction. The incorporation of compost or manure into the soil also increases infiltration. It should be noted that tilling this deep may require special equipment.
- In areas where flatter lot grading is implemented, roof leaders that discharge to the surface should extend 6 feet away from the building.

Construction

- Soil compaction must be avoided wherever possible. For example, vehicles should never be parked on the future lawn during construction.
- Mass grading should be avoided to keep native soil profiles intact and to minimize the area of soil compaction.
- If soils become compacted through construction activities, the soil should be tilled to 18 inches and 6 to 12 inches of organic compost should be incorporated into the soil.

Soakaway Pits

Description

Soakaway pits, also known as downspout infiltration systems, roof leader infiltration systems and dry wells, can be distinguished from infiltration trenches in terms of scale and sophistication of design. Soakaway pits are designed to receive runoff from individual roof leaders, whereas infiltration trenches are used for large-lot applications (see the Infiltration Trenches BMP section for more detail).

Soakaway pits are small, excavated pits, backfilled with aggregate, used to infiltrate "good quality" stormwater runoff, such as uncontaminated roof runoff. Rooftop runoff is discharged to the soakaway pit through the roof leader, which extends directly into a stone-filled reservoir. Figures 2 through 4 show examples of soakaway pit designs.

The use of soakaway pits is limited by a number of site constraints, including soil type, contributing drainage area, depth to bedrock, and depth to groundwater. Rooftop gutter screens are needed to trap particles, leaves and other debris, and must be cleaned regularly.

Soakaway pits for roof leader drainage have been implemented in Toronto, Maryland and Europe. A monitoring study indicated that 60 percent of 25 soakaway pits studied were operating as designed (Lindsey et al., 1992).

Design Guidelines

If a formal, detailed design is required by local permitting authorities, the design requirements presented in the Infiltration Trench BMP section can be followed for the design of soakaway pits (although no pretreatment other than gutter screens is required of a soakaway pit that receives only roof runoff). Other design considerations include:

On-Lot Infiltration

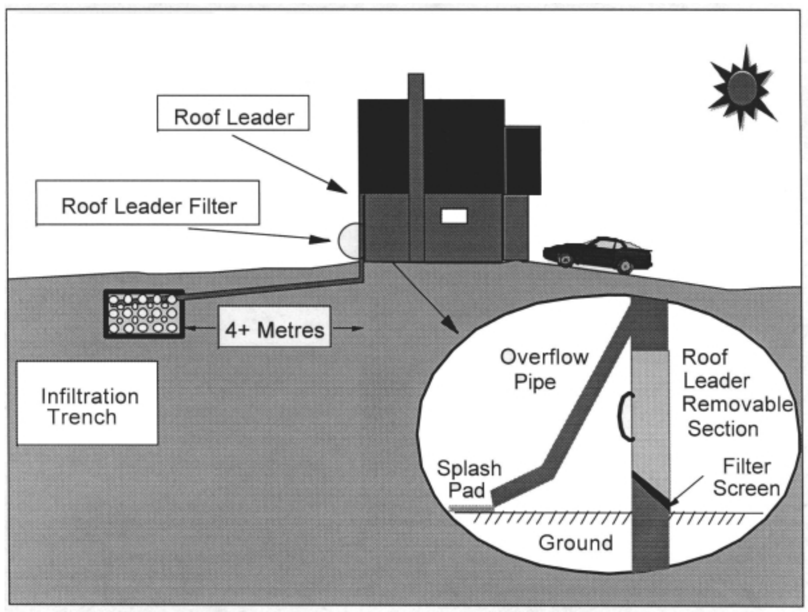


Figure 2: Roof Leader Discharge to Soakaway Pit
Source: Ontario Ministry of the Environment, 1999

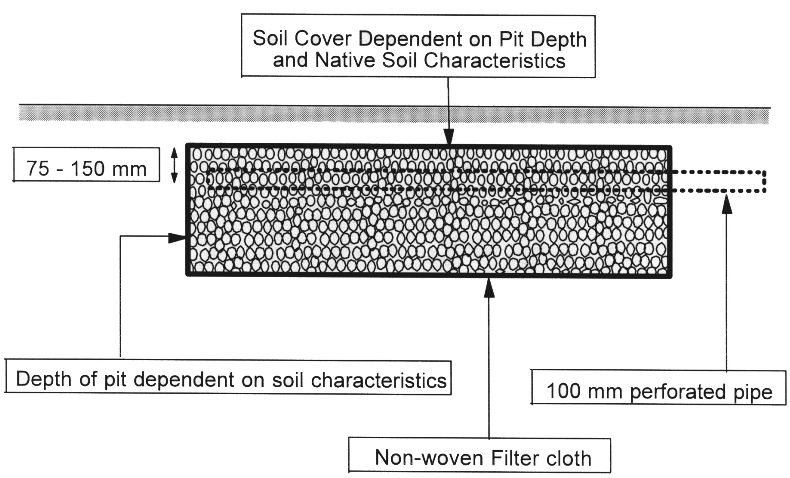


Figure 3: Soakaway Pit Details
Source: Ontario Ministry of the Environment, 1999

Soakaway Pits (continued)

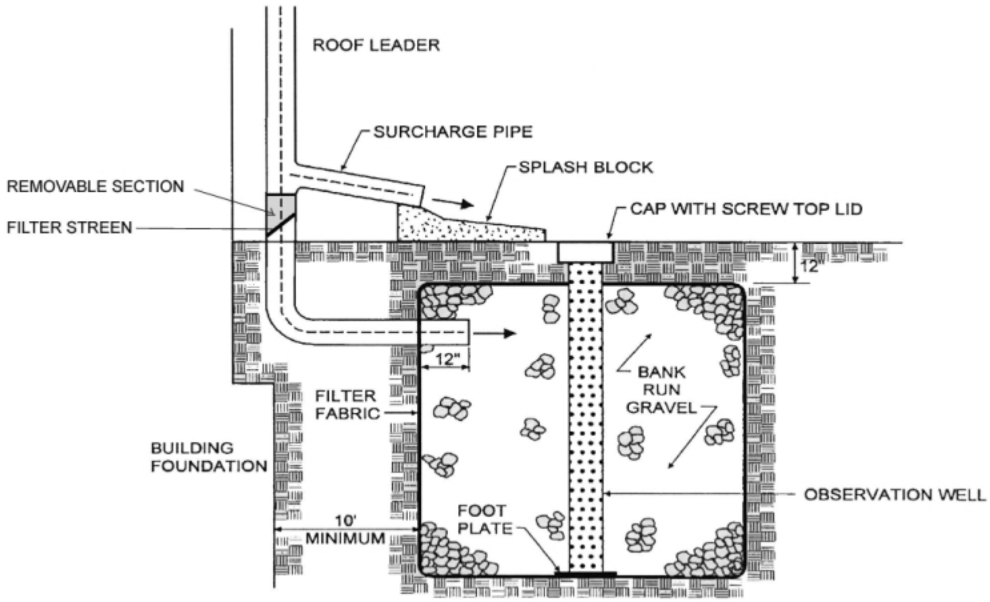


Figure 4: Soakaway Pit Profile
Source: Adapted from Maryland Department of the Environment, 1998.

- The soakaway pit should be located at least 10 feet away from the foundation of the nearest building to prevent foundation damage.
- The extension of a roof leader into a pit may span the full length of the pit (Figures 2 and 3). This extension consists of a perforated pipe, allowing water to fill the pit along the length of the pipe. The perforated pipe should be located near the surface of the trench (3 to 6 inches from the top of the pit).
- An overflow pipe should be installed from the roof leader to discharge to a splash pad. A removable filter should be incorporated into the roof leader below the overflow pipe.
- Typically the pit should be located close to the ground surface; however, this will depend on the depth of storage in the pit, the potential for frost heave, and the stratification of the surrounding soil media. The potential for frost heave is dependent on the surrounding native soils and the potential volume of water in the trench that can freeze. Figure 5 provides guidance on the recommended minimum soil cover for various subsurface trench depths and native soil media. This curve has been produced based on professional opinion, the expansion of water due to freezing, and the potential availability of water to freeze (Ontario, 1999).
- Barring other site considerations, the maximum depth of the pit can be determined from the infiltration rate, the allowable storage time, and the void space. Since the soakaway pit is filled with stone, only the space between the stones is available for runoff storage. Soakaway pits are to be filled with 1.5- to 3-inch-diameter clean-washed stone. This size stone will yield a void space of approximately 30 to 40 percent.

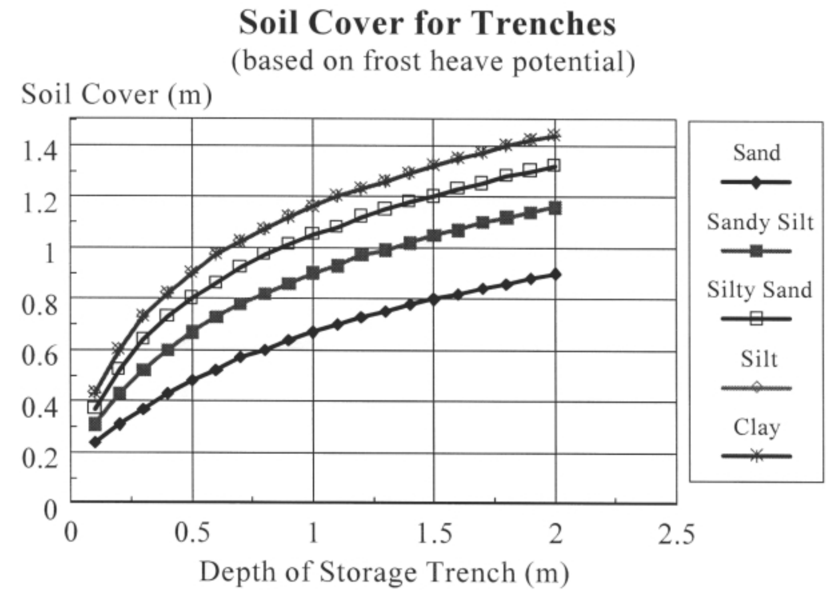


Figure 5: Recommended Soil Cover for Soakaway Pits

Source: Ontario Ministry of the Environment, 1999

- Storage depths greater than 5 feet are generally not recommended for soakaway pits from both a cost and a compaction perspective. The weight of the water in a deep soakaway pit will compact the surrounding native soil and decrease the infiltration capacity. There are exceptions, however, to this maximum depth recommendation. In areas with deep sand lenses or significant horizontal soil stratification, deep soakaway pits may be preferred. Soils investigations should be undertaken to determine whether these situations exist.
- A maximum storage time of 72 hours is recommended. It is recommended that a conservative drawdown time (such as 24 hour) be chosen for design in recognition of the fact that the percolation rates into the surrounding soil will decrease over time and that there will likely be a lack of maintenance in some cases.
- The length of trench (in the direction of inflow) should be maximized compared to the width to ensure the proper distribution of water into the entire trench and to minimize the potential for groundwater mounding (groundwater mounding is a local increase in the water table due to the infiltration of water and is more prevalent if a greater volume of water infiltrates in a localized area; square trenches will have greater groundwater mounding).
- A minimum storage volume of 0.2 inches over the rooftop area should be accommodated in the soakaway pit without overflowing. The maximum target storage volume should be approximately 0.8 in over the rooftop area since a vast majority of all daily rainfall depths are less than this amount.

Maintenance

- Since these structures are often installed at single-family dwellings, it is important that developers outline the maintenance requirements to property purchasers clearly.
- A removable filter should be incorporated into the roof leader below the overflow pipe. The filter should have a screened bottom to prevent leaves and debris from entering the soakaway pit. It should be easy to remove so

that a homeowner can clean the filter. Frequent use of the overflow pipe will indicate the need for filter screen maintenance.

- See the Infiltration Trench BMP Section for more detailed information on construction and maintenance criteria.

Rain Barrels

Description

Rain barrels, also known as cisterns, are aboveground storage vessels that receive roof runoff from roof leaders. Rain barrels have either a manually operated valve or a permanently open outlet that allows storage and slow release of roof runoff.

If the rain barrel has an operable valve, the valve can be closed to store stormwater for irrigation use or infiltration between storms. This is particularly useful in areas with tight soils, where infiltration is slow, resulting in wet areas for an extended period of time. If water is stored inside for long periods, the rain barrel must be frequently monitored and should be covered to prevent mosquitoes from breeding.

If the rain barrel's valve is kept open, and if the barrel's outlet is significantly smaller than the size of the downspout inlet (for example, a quarter- or half-inch diameter outlet), runoff will build up inside the rain barrel during storms, and will empty out slowly after peak intensities subside. This is a feasible way to mitigate the peak flow increases caused by rooftop impervious land coverage, especially for frequent, small storms.

Figure 6 shows a typical rain barrel.

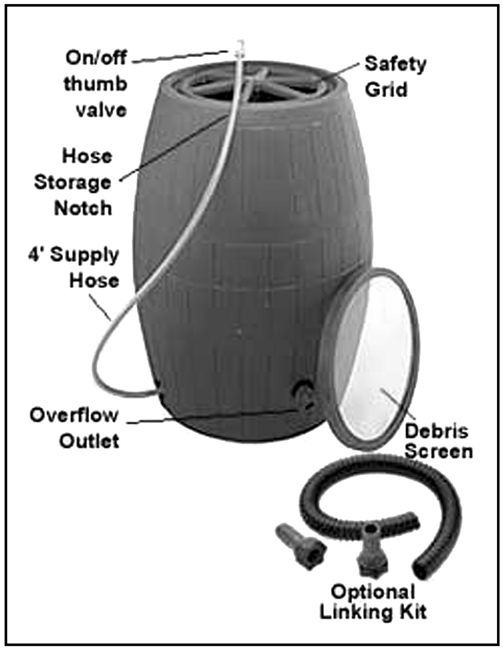


Figure 6: Typical Rain Barrel
Source: Gardener's Supply Company, 2001

Design Guidelines

- Rain barrels can be incorporated into the aesthetics of buildings and gardens. Japanese, Mediterranean and American southwest architecture provide many examples of attractive rain barrels made of a variety of materials.
- If a rain barrel holds more than a 6-inches depth of water, it should be covered securely or have a top opening of 4 inches or less to prevent small children from gaining access to the standing water.
- The rain barrel should be designed and maintained to minimize clogging by leaves and other debris.
- Small rain barrels and rain barrel disinfection systems are available commercially.

Maintenance

- In cold winter climates, the barrel and outlet hose should be completely drained and the barrel placed upside-down to avoid freezing and cracking during the winter.
- The rain barrel should be cleaned out once per year.

On-Lot Infiltration

Rainwater Gardens

Description

Rainwater gardens are small, vegetated depressions used to promote infiltration of stormwater runoff. Runoff enters the gardens via sheet flow. Rainwater gardens can be planned and integrated into both new and existing developments. A rainwater garden combines shrubs, grasses, and flowering perennials in depressions (about 6 to 18 inches deep) that allow water to pool for only a few days after a rain. Vegetation is vital to the proper function of a rainwater garden. Water is detained in the ponding area until it either infiltrates or evaporates. The plants in the rainwater garden help to infiltrate the water and trap pollutants for a very low cost.

Rainwater gardens placed along the front-yard public easement can capture runoff from city streets and lawns and filter it before it enters local lakes, wetlands, streams or groundwater.

Rainwater gardens can be incorporated into many different areas, such as:

- Front and back yards of residential areas
- Parkway planting strips
- Road shoulder rights-of-way
- Parking lot planter islands
- Under roof downspouts

Figures 7 through 10 show some examples of rainwater garden designs.

Design Guidelines

Design of rainwater gardens can be simple or complex, depending on the level of effort one is willing to put into it. Some general design guidelines include:

- The area for ponding should be a shallow depression of 6 to 18 inches.
- The area of ponding should be greater than 10 feet away from any building foundations to ensure that the ponded water does not drain to foundations.
- There are several alternative combinations of parts for constructing front-yard easement gardens that make them more attractive to people. The essential elements include perennial flowers, ornamental grasses, shrubs and neat edges created by attractive walls, pavers or a band of turf. Many combinations of these elements are shown in *Bringing Garden Amenities Into Your Neighborhood* (Nassauer et al., 1997); a few examples are shown in Figures 8 through 10.
- Plants in the easement gardens can be selected to reduce maintenance and to tolerate snow storage and winter salt and sand. The suggested plant list on the last page of this BMP section provides recommendations for appropriate plants based on different site conditions (Rozumalski, 2001).
- Rainwater gardens should be designed with the tallest flowers and shrubs in the deepest part of the swale. However, these plants should stay short enough that they will not obstruct the view to houses. Shrubs should be pruned annually to keep a low profile, set within the swale.

On-Lot Infiltration

Rainwater Gardens (continued)

- In order to maintain treatment effectiveness and storage volume, runoff from roads and other impervious surfaces must be pretreated before entering the basin. The simplest pretreatment scheme is to move water via sheet flow over at least 4 feet of turfgrass that slopes no more than 10 percent.
- Compaction of the soil in a rainwater garden should be avoided during construction in order to maintain basins' infiltration capacity. If compaction does occur, soils should be ripped to a depth of 18 inches, with 6 to 12 inches of organic compost incorporated into the till prior to planting.

Maintenance

- If gardens are properly planned and designed (protected from sediment and compaction and incorporating a sufficient turf pretreatment area), a rainwater basin is likely to retain its effectiveness for well over 20 years. After that time, inspection will reveal whether sedimentation warrants scraping out the basin and replanting it (possibly with salvaged plants).
- In the first year, rainwater gardens require vigilant weeding (monthly during the growing season). The need for weeding will decrease as plants become established.
- In the spring, standing dead plant debris will need to be removed.
- The rainwater garden should be inspected annually for sediment trapped in the pretreatment area and in the garden itself.
- Shrubs should be pruned as necessary to keep a neat appearance.

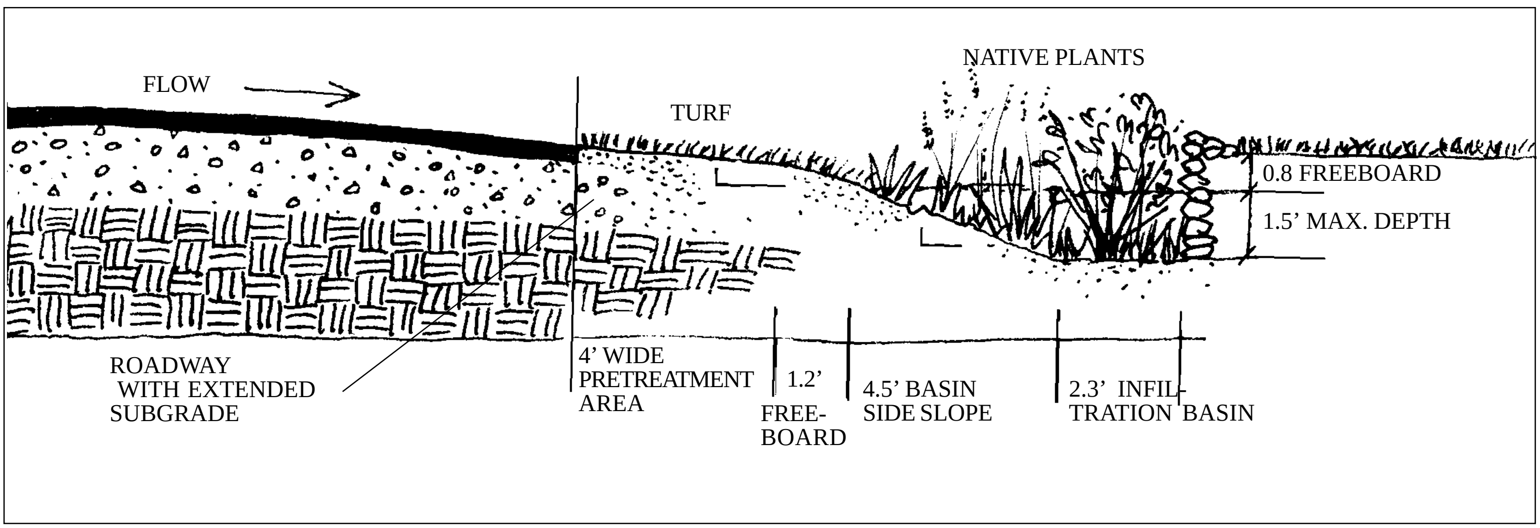


Figure 7: Profile of a Typical Rainwater Garden

Source: Valley Branch Watershed District, 2000

On-Lot Infiltration

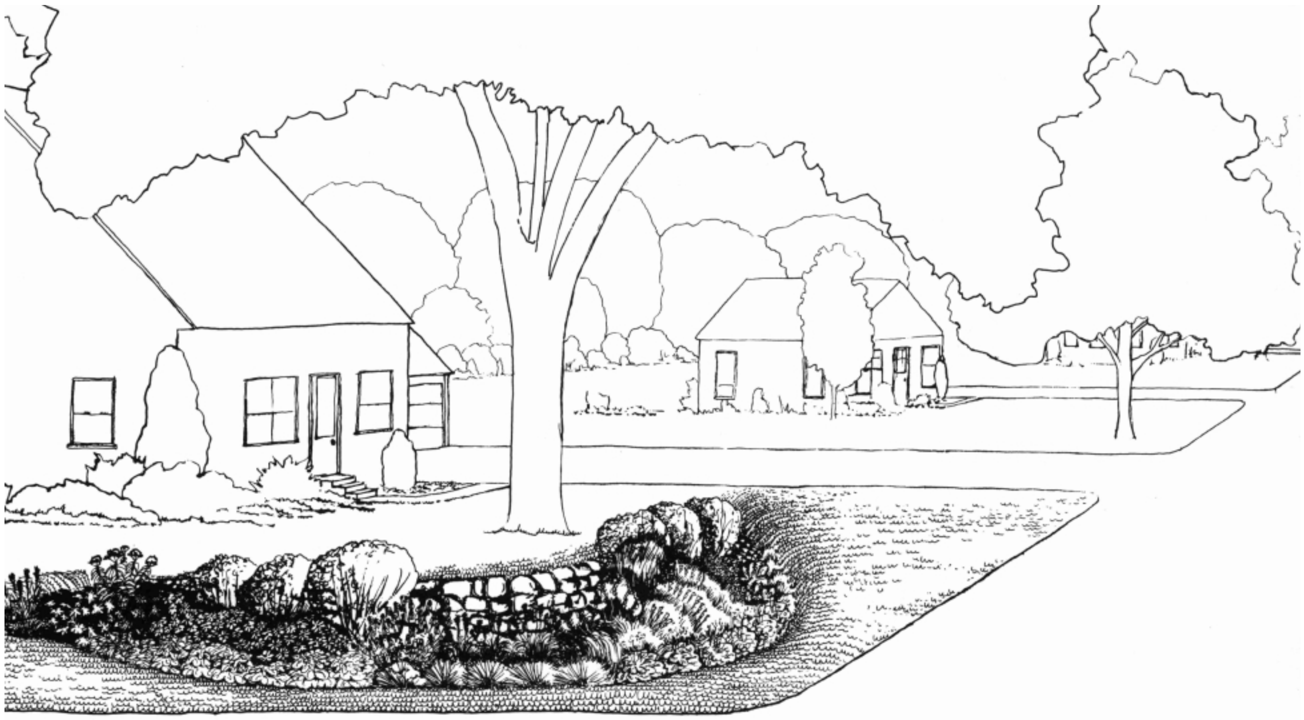


Figure 8: Typical Rainwater Garden Layout
Source: Adapted from Nassauer et al., 1997.

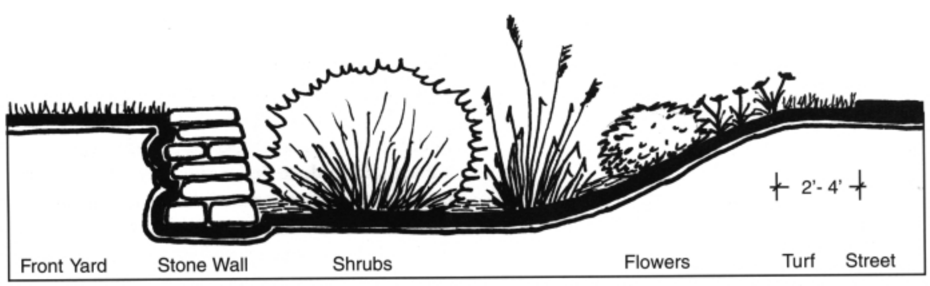


Figure 9: High-Volume, Asymmetrical Rainwater Garden with Masonry Wall
Source: Adapted from Nassauer et al., 1997.

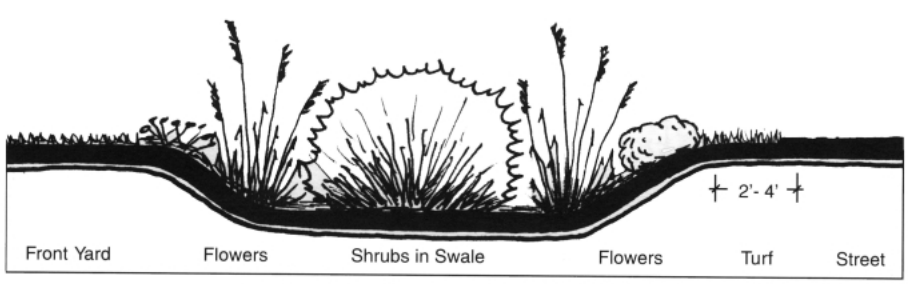


Figure 10: High-Volume, Symmetrical Rainwater Garden
Source: Adapted from Nassauer et al., 1997.

On-Lot Infiltration

Rainwater Gardens Plant List

Source:Fred Rozumalski

Mesic-Dry Soils (Sunny)

Native

Butterfly Flower	*Asclepias tuberosa*
Purple Prairie Clover	*Dalea purpureum*
Purple Coneflower	*Echinacea purpurea*
Bee balm	*Monarda fistulosa*
Little Bluestem	*Schizachyrium scoparium*
Spiderwort	*Tradescantia bracteata*

Non-Native

Yarrow “Coronation Gold”	*Achillea “Coronation Gold”*
Feather Reed Grass “Karl Foerster”	*Calamogrostis “Karl Foerster”*
Daylily	*Hemerocallis spp.*
Blazingstar “Kobold”	*Liatris “Kobold”*
Silverfeather Grass	*Miscanthus sinensis*
Garden Phlox	*Phlox paniculata*
Black-Eyed Susan “Goldsturm”	*Rudbeckia fulgida “Goldsturm”*

Mesic-Dry Soils (Shady)

Native

Wild Columbine	*Aquilegia canadensis*
Wild Geranium	*Geranium maculatum*
Obedient Plant	*Physostegia virginiana*
Jacob’s Ladder	*Polemonium reptans*
Solomon’s Seal	*Polygonatum biflorum*
Zigzag Goldenrod	*Solidago flexicaulis*
Canada Violet	*Viola canadensis*
Culver’s Root	*Veronicastrum virginium*

Non-Native

White Comfrey	*Symphytum grandiflorum*
Tufted Hair Grass	*Deschamsia caespitosa*
Bigroot Geranium	*Geranium macrorrhizum*
Daylily	*Hemerocallis spp.*
Hosta “Royal Standard”	*Hosta “Royal Standard”*
Tigerlily	*Lilium tigrinum*

Wet Soil (Sunny)

Native

Giant Hyssop	*Agastache foeniculum*
Canada Anemone	*Anemone canadensis*
Marsh Milkweed	*Asclepias incarnata*
New England Aster	*Aster novae-angliae*
Turtlehead	*Chelone glabra*
Joe-Pye Weed	*Eupatorium maculatum*
Obedient Plant	*Physostegia virginianum*
Boneset	*Eupatorium perfoliatum*
Queen of the Prairie	*Filpendula rubra*
Blueflag Iris	*Iris versicolor*
Great Blue Lobelia	*Lobelia siphilitica*
Switchgrass	*Panicum virgatum*
Mountain Mint	*Pycnanthemum virginianum*
Tall Meadow Rue	*Thalictrum dasycarpum*
Culvers Root	*Veronicastrum virginicum*
Golden Alexander	*Zizia aurea*

Non-Native

Joe-Pye “Gateway”	*Eupatorium purpurescens “Gateway”*
Daylily	*Hemerocallis spp.*
Siberian Iris	*Iris sibirica*
Tigerlily	*Lilium tigrinum*
Switchgrass “Heavy Metal”	*Panicum virgatum “Heavy Metal*”

On-Lot Infiltration

Wet Soils (Shady)

Native

Cardinal Flower	*Lobelia cardinalis*
Ostrich Fern	*Matteuccia struthiopteris*
Virginia Bluebells	*Mertensia virginica*
Sensitive Fern	*Onoclea sensibilis*

Non-Native

Pink Turtlehead	*Chelone layonii*
Daylily	*Hemerocallis spp.*
Obedient Plant	*Physostegia virginiana*

Shrubs (Sunny)

Black Chokeberry	*Aronia melanocarpa*
Red-Osier Dogwood	*Cornus serecia*
Low Bush Honeysuckle	*Diervilla Ionicera*
Annabelle Hydrangea	*Hydrangea arborescens "Annabelle"*
Pussy Willow	*Salix discolor*
High Bush Cranberry	*Viburnum trilobum*

Shrubs (Shady)

Black Chokeberry	*Aronia melanocarpa "alata"*
Red-Osier Dogwood	*Cornus sericia*
Low Bush Honeysuckle	*Diervilla Ionicera*
Annabelle Hydrangea	*Hydrangea arborescens "Annabelle"*

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